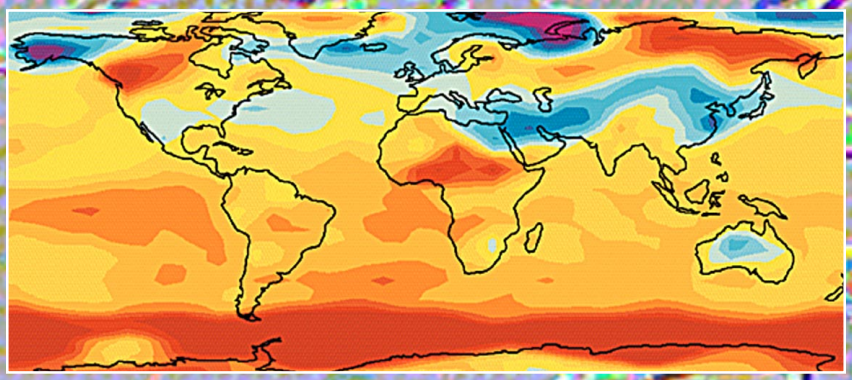


MEETING ENDURING NATIONAL NEEDS

We seek challenges where taking technical risks can lead to high payoffs and make important contributions to national well-being.

The Department of Energy has enduring missions that are vital to the national interest. In addition to its national security mission, the Department's priorities include enhancing the nation's energy security and developing and making available clean energy, cleaning up former nuclear weapons sites and finding a more effective and timely approach to nuclear-waste disposal, and leveraging science and technology to advance fundamental knowledge and economic competitiveness.

Livermore's strengths are well matched to the Department's needs, particularly in areas with high payoffs that entail significant scientific and technical risk. We pursue major projects where we can make unique and valuable contributions. These activities build on and reinforce the Laboratory's key strengths. The nation benefits from the application of Livermore's special skills to a wide range of national problems and from the cross-fertilization of ideas that occurs. In turn, program diversity keeps the Laboratory vital and helps to sustain the multidisciplinary base needed for national security work.

ENERGY SECURITY AND LONG-TERM ENERGY NEEDS

The Laboratory's research focus will be on significant innovations in energy production and usage. The availability of affordable energy has been the foundation of U.S. prosperity and economic growth. At present, energy is relatively cheap and abundant and is of little concern to most Americans. However, the U.S. imports about 50% of the oil it consumes, and much of the world's supply comes from a politically volatile Middle East. With total world energy consumption growing at nearly 20% per decade, competition for energy in the international marketplace will increase dramatically.

The future security of our nation will depend on access to abundant energy sufficiently clean to preserve the environment. We will work with the Department of Energy to design an energy research and development portfolio that meets the needs of the 21st century. Livermore will pursue programs in fusion energy, nuclear fuel cycle improvements, nuclear systems safety, and hydrogen fuel.

Fusion Energy

Energy production from nuclear fusion is a long-standing goal at Livermore. Research efforts build on and reinforce our national security activities, which provide Livermore the advantage of combined strengths in nuclear science, scientific computing, laser technologies, and engineering. These capabilities will focus on identifying and pursuing the most promising path to full-scale deployment of fusion power. We will conduct inertial fusion experiments with the National Ignition Facility and pursue advanced magnetic confinement fusion schemes. We also seek to maintain the Laboratory's major role in the U.S. program on the International Thermonuclear Experimental Reactor.

In global climate research, Livermore applies advanced computing techniques to assess the effects of carbon dioxide and sulfate aerosols.

In the National Ignition Facility, we expect to create—for the first time ever in a laboratory setting—bursts of self-sustaining fusion reactions.

• **Demonstration of Inertial Fusion Ignition and Burn.** In the National Ignition Facility, we expect to create—for the first time ever in a laboratory setting—bursts of self-sustaining fusion reactions. This physics demonstration will be conducted in parallel with a research program on fusion driver concepts (ion-beam accelerators and lasers) to meet the efficiency and repetition-rate requirements of inertial fusion power plants.

• **Magnetic Spheromak Experiments.** The spheromak is an alternative to the tokamak that might lead to smaller, less-expensive fusion reactors. We will pursue experiments to achieve sustained spheromak operation and will resolve key scientific issues to advance the design of magnetic fusion systems.

• **Integrated Fusion Modeling.** We will use the unprecedented computing capability that we are acquiring to enhance inertial fusion simulations and large-scale integrated modeling of magnetic fusion experiments. The latter goal, probably a decade away, will include coupling individual magnetic fusion physics codes using the parallel architecture of the new supercomputers used for stockpile stewardship.

Atomic Vapor Laser Isotope Separation

In a 20-year-long effort, Livermore has been developing the atomic vapor laser isotope separation (AVLIS) process for enriching uranium for reactor fuel at reduced cost and environmental impact. The goal culminates with the largest technology transfer in government history—the successful commercialization of AVLIS by the U.S. Enrichment Corporation (USEC).

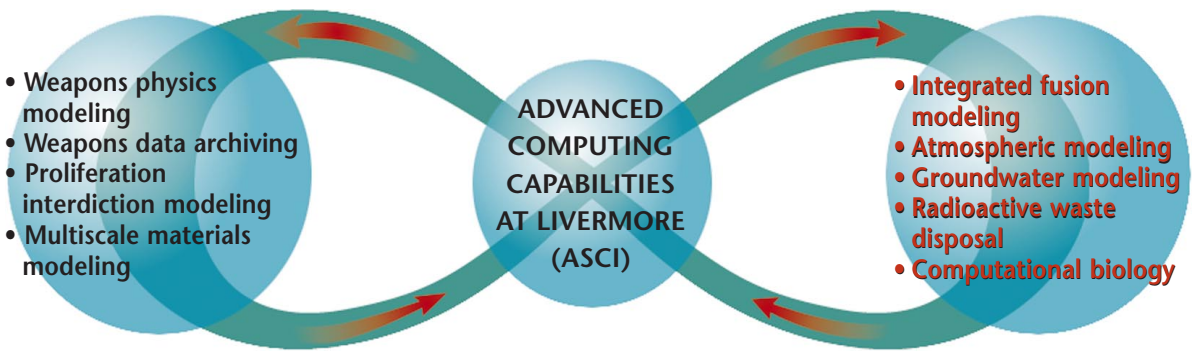
• **Production-Plant-Scale AVLIS.** USEC is taking preliminary steps to construct a production AVLIS facility, and Livermore has the lead role for design and deployment of the special process equipment. Working for the USEC, we will demonstrate uranium-AVLIS at production-plant scale and assist in plant design and deployment.

Advanced Energy Technologies

We will partner with U.S. industry to develop hydrogen fuel technologies, advanced fuel cells and flywheels for energy generation and storage, and high-precision manufacturing technologies that reduce waste and consume less energy.

• **Hydrogen Fuel.** In a collaborative effort of national laboratories and U.S. industry, we will develop technologies to use hydrogen fuel as a clean, accessible alternative to petroleum products for use in transportation systems. We will evaluate systems issues and tradeoffs, establish partnerships for advanced demonstration programs, and develop technologies for efficient hydrogen production, storage, and use. The overall program goal is to introduce into the marketplace environmentally benign automobiles that are performance competitive with gasoline-powered vehicles.

Opportunities Created by Advanced Computing



The Accelerated Strategic Computing Initiative (ASCI), required for stockpile stewardship, enables the Laboratory to respond to other program opportunities.

We are at the threshold of a new era in environmental simulations, with the potential to assess and predict environmental phenomena with unprecedented speed and accuracy.

ENVIRONMENTAL ASSESSMENT AND MANAGEMENT

The Department of Energy has major environmental responsibilities. Dealing with the legacy of Cold War nuclear weapons production is a monumental task, estimated to cost $200 billion to $350 billion. In addition, the Department shoulders the broad responsibility of understanding—and anticipating—the local, regional, and global impacts of energy use and other human activities on the biosphere.

Livermore will assist the Department and the nation in two significant ways. First, at the Livermore site we have developed and field tested broadly applicable technologies for environmental remediation. Second, the Laboratory will greatly enhance the nation's ability to predict and respond to manmade environmental hazards and natural changes that affect weather or climate.

Environmental Remediation and Regulation

The Laboratory has well-demonstrated capabilities for measurement of organic and radioactive contaminants, science-based risk assessment, and environmental remediation. Livermore completed the first cleanup of a major underground fuel contamination at a national laboratory. We also have developed unique tools for predicting the transport, deposition, and human impact of radioactive and toxic materials in the ecosystem. In addition to their contribution to environmental management of the Livermore site, these capabilities are applied to national security work at the Laboratory (e.g., technologies to monitor proliferation activities) and projects concerning important environmental issues.

As an example, we recently used these tools to examine underground fuel tank contamination in California; the study's findings may save over $1.5 billion in cleanup costs. Livermore is able to assist regulatory agencies in placing cleanup standards on a science-based footing.

• **Accelerated Site Cleanup.** We will propose to the Department of Energy an Accelerated Cleanup Initiative to demonstrate at Livermore novel, cost-efficient technologies for soil and groundwater cleanup. Livermore's cleanup requirements are similar to those for many Department of Defense sites, which must undergo remediation before release for public use. We will also offer to collaborate with the Department of Defense in cleanup technology demonstrations that will include corporate partners. These activities will validate the performance and the economics of the new technologies.

• **Improved Environmental Toxicology.** We will form an academic–industrial consortium to develop a realistic, scientific risk basis for environmental regulation of toxic chemicals. Livermore's Center for Accelerator Mass Spectrometry offers an extremely sensitive measurement capability for determining the mutagenic and carcinogenic potency of common chemical pollutants. We will include the regulatory agencies in this activity to ensure their confidence in and use of the results.

Livermore's design of a regenerative fuel cell, which uses the hydrogen fuel that the fuel cell creates during charge-up, has potential for transportation and other uses.

Assessment and Prediction of Atmospheric Processes

With the advent of terascale supercomputing at the Laboratory, we are at the threshold of a new era in environmental simulations, with the potential to assess and predict environmental phenomena with unprecedented speed and accuracy. Livermore is advancing global climate

We are developing regional predictive capabilities for precipitation and runoff that are operationally useful for weather emergencies and resource management.

simulation by improving the models of dynamical and chemical processes in the atmosphere, coupling models of atmospheric and oceanic circulation, increasing the spatial resolution of calculations, and including more accurate treatments of aerosols, trace gas constituents, and carbon isotopes. We will improve predictive accuracy, to be validated by very sensitive new tests of climate change parameters. In addition, we are combining expertise in geophysical and atmospheric simulation to develop predictive models of regional-scale hydrological processes and of the transport and dispersion of hazardous materials. Livermore models are used for operational response to weather-related incidents and for natural resource management. These capabilities complement our National Atmospheric Release Advisory Center, a source of real-time emergency predictions worldwide if radioactive or chemical materials are released into the atmosphere.

• **Multiscale Atmospheric Prediction**. With Livermore's increasingly powerful computers, we will improve the spatial resolution, physics fidelity, and predictive accuracy of both our global and regional models. We will explore linking these models with one another and with data flows from satellites and other distributed measurement systems to establish a powerful operational capability and research tool for both military and civilian applications. This multiscale atmospheric prediction and assessment capability will permit effective responses to natural and manmade hazards and changes. The goal is to apply this comprehensive modeling system to anticipate, assess, and manage natural or deliberate threats to the health, safety, sustainability, and security of the U.S. environment.

NUCLEAR MATERIALS STEWARDSHIP

The Laboratory can serve as an effective national technical resource in the production, use, and disposition of nuclear materials. Many continuing activities in the Department of Energy involve nuclear materials because of its responsibility for the storage and ultimate disposition of U.S. spent reactor fuel and other nuclear wastes. Livermore's broad foundation of nuclear expertise and capabilities will help the Department to develop safe, secure, efficient, and environmentally responsible methods for all nuclear operations.

As a natural outgrowth of national security activities, much of Livermore's research involves nuclear science and nuclear materials. Major efforts include the safe and secure disposition of Cold War–legacy nuclear materials, commercialization of uranium laser isotope separation, and projects to improve nuclear systems safety. We are also working on the development of a consistent, science-based regimen for the categorization, risk assessment, and management of nuclear materials. We will provide expertise, analysis, and technologies to help the Department develop a comprehensive program for stewardship of nuclear materials.

• **Yucca Mountain Repository Assessment and Implementation.** The country faces a unique technical, institutional, and political challenge in the management and ultimate disposition of high-level nuclear waste. Livermore can contribute to the success of the program by providing an integrated simulation and analysis of repository designs and performance and plans for optimum licensing, loading, and monitoring.

The Human Genome Project is creating material resources, technologies, and information to set the stage for dramatic advances in the next century.

ADVANCING BIOSCIENCES TO IMPROVE HUMAN HEALTH

Livermore is part of an accelerating revolution in biology and biotechnology. The groundwork for this revolution was laid in the 1980s with a shift of the national research strategy toward large-scale, complex projects, notably the Human Genome Project. This project, in which Livermore is a significant participant, is creating material resources, technologies, and information to set the stage for dramatic advances in the next century. We developed breakthrough technological tools that have enabled program success—methods for high-speed sorting of individual chromosomes and for measuring distances between DNA markers. Livermore is collaborating with Lawrence Berkeley and Los Alamos national laboratories in the Department of Energy's Joint Genome Institute.

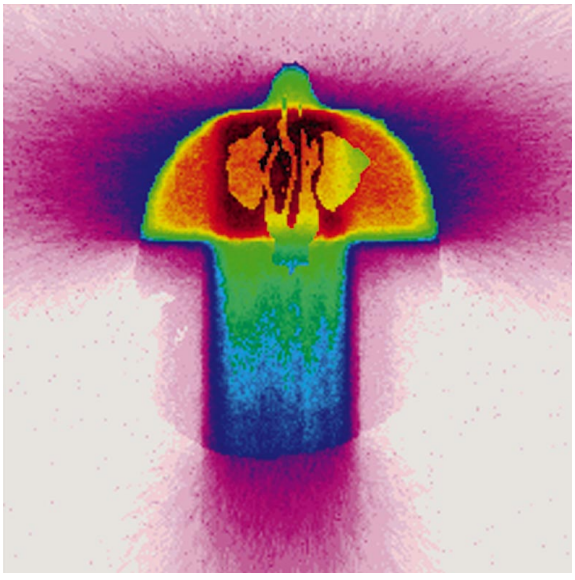
The marriage of engineering and science that occurs at Livermore greatly strengthens the Laboratory's bioscience research and enables important advances in biotechnology. Conversely, Laboratory bioscientists make significant contributions to national security activities and other major programs. For example, we are developing detection technologies to monitor and characterize biological weapon proliferation activities and to respond in the event of an emergency.

Livermore's bioscience program grew out of a long-standing biomedical research mission to identify and characterize the effects of ionizing radiation on human health, which led to the development of sensitive instrumentation for genomics research.

For many years, most of the program's funding came from the Department of Energy's Office of Health and Environmental Research; now about half of the funding comes from other sources such as the National Institutes of Health. Because bioscience is a very cost-competitive field, the program will greatly benefit (as will many other programs) from steps the Laboratory is taking to reduce the cost of doing business and to find new ways to facilitate interactions with industrial partners.

• **Genomics.** The goal is to use genomics information to enhance our nation's security, preserve our environment, and ensure a better quality of life. In the course of developing a very-high-resolution map of human chromosome 19, we created unique research capabilities that make it relatively straightforward to isolate and characterize genes of interest in almost any species. Livermore's emphasis on gene discovery and high-throughput DNA sequencing will greatly benefit from our development of robotics technologies that minimize repetitive tasks and reduce costs. In the process of generating highly accurate DNA sequences, we will maintain, characterize, and analyze a collection of genes. Livermore will provide for public access to these data and analysis tools.

• **Disease Susceptibility and Prevention.** We are examining the relationship between an individual's genes and health risks from adverse environments. This research includes efforts to identify genes that determine individual susceptibility, to understand how the proteins that these genes encode might be involved in the disease process, and, finally, to estimate risk for disease based upon an individual's genetic constitution and environmental exposure. These activities will draw upon Livermore's expertise in molecular genetics, as well as bioscience and bioengineering.



A cross section of an absorbed radiation dose for treating cancer of the brain is shown after calculation by the Laboratory's Peregrine radiation planning system, which will improve cancer treatment.

• **Health Care and Medical Biotechnology.** The goal is to develop cost-effective healthcare technologies with high impact on disease prevention, diagnosis, and treatment. Livermore's Center for Healthcare Technologies serves as a coordinating and marketing focal point for projects that combine the Laboratory's expertise in sensors, imaging, computational physics, informatics, microfabrication, and lasers with university and industry knowledge in biomedicine. For example, Livermore is developing novel methods and surgical tools for the treatment of stroke, and we are adapting physics simulation capabilities into a unique planning tool (Peregrine) for radiation treatment of cancer. More than 350,000 Americans each year who are diagnosed with a "curable" form of the disease could benefit. We will explore the establishment of a molecular medicine program to couple our strengths in molecular and cellular biology to the development of diagnostic instruments and ultimately to clinical treatment.

PURSUING BREAKTHROUGHS IN FUNDAMENTAL SCIENCES AND APPLIED TECHNOLOGY

One of Secretary of Energy Federico Peña's four key priorities is to ensure that the U.S. maintains its world leadership in science and technology. It is widely recognized that the nation's advances of fundamental knowledge and innovation provide the U.S. an advantage in an increasingly competitive world.

The pursuit of fundamental science and the advance of applied technology go hand in hand at Livermore. State-of-the-art applied technology is used to advance fundamental science, most frequently in areas pertinent to the Laboratory's major missions and often using Laboratory Directed Research and Development as an initial source of funding. For example, we have successfully demonstrated that laser guide star adaptive optics can correct for atmospheric turbulence. Livermore's development and installation of a laser guide star system on the 10-meter-diameter Keck II Telescope on Mauna Kea, Hawaii, will significantly improve the quality of its images.

The Laboratory's scientific advances—and technologies developed in the pursuit of fundamental science—have important spin-off and spin-back applications. The laser guide star technology is helping us in the design of the National Ignition Facility. The discovery of fluid metallic hydrogen—a new state of matter—contributes to planetary science and generates new knowledge about the properties of hydrogen needed for Laboratory programs. Livermore's petawatt laser enables physics experiments never before possible and also has precision cutting applications for advanced manufacturing in stockpile management and broader applications. Technologies developed to build the petawatt laser are enabling revolutionary advances in flat-panel displays for computers and television sets.

• **Astrophysics and Space Science.** In partnership with many other scientific institutions, we will continue to make important advancements in astrophysics and space science through application of the Laboratory's special expertise in high-energy-density physics, nuclear fusion, and scientific computing. As we improve material-property models and simulation codes in support of stockpile stewardship, we will make discoveries about stellar evolution and other high-energy astrophysics processes. Livermore also makes important advances in instrumentation, as

A laser physicist adjusts a diagnostic lens in Livermore's ultrashort-pulse petawatt laser.

The Laboratory's scientific advances—and technologies developed in the pursuit of fundamental science—have important spin-off and spin-back applications.

demonstrated by the development of sensors for the Clementine satellite, which mapped the entire surface of the Moon at resolutions never before attained. This sensor technology is leading to other advances, such as the development of a revolutionary camera system and its use to discover massively compact halo objects (MACHOs).

• **Accelerator Technology.** We will continue to make strong contributions to national accelerator development programs, capitalizing on the way our physicists and engineers work together to solve problems in accelerator design, technology, and manufacturing. Livermore is part of the three-laboratory collaboration building the B-Factory at the Stanford Linear Accelerator Center, an effort at the forefront of high-energy physics research. We are also collaborating on the development of the Next Linear Collider. Livermore's accelerator expertise has important national security applications for the development of Accelerator Production of Tritium and the Advanced Hydrotest Facility.

• **Micro-electronics and Opto-electronics.** The Laboratory's strengths in micro-electronics and opto-electronics will help meet the demands for enhanced surveillance of aging nuclear weapons as well as for advanced diagnostics and precision target fabrication in the inertial confinement fusion program. Expertise in thin-film processing and microfabrication technology has many applications in lithography, semiconductor processing and process modeling, electronics packaging, communication and computing systems, and biotechnology. We will pursue, in partnership with U.S. industry, the development of lithography technologies that are pivotal in producing the next generation of integrated circuits.

• **Advanced Materials.** In support of Laboratory programs, we engineer novel materials at the atomic or near-atomic levels and carry development of these materials to the stage where they can be readily manufactured. Aerogels and nano-engineered multilayer materials are examples of Livermore advances that have tremendous implications for new products and future Laboratory programs. Advances include highly efficient energy-storage and energy-generation components, ultra-lightweight structural materials, tailored coatings, and novel electronic, magnetic, and optical materials.

• **Laser Science and Technology.** The Laboratory has unmatched capabilities in high-energy and high-power, solid-state lasers. We will apply this expertise to meet critical needs in national security, energy security, and environmental applications. We will continue to lead the world in studying the interaction of intense radiation with matter. Livermore will expand collaborations with industry and other partners to identify laser and electro-optics technologies that can be developed and transferred to the private sector.

Livermore precision machining experts produce specialized radiofrequency cavities for the B-Factory at the Stanford Linear Accelerator Center. It will be used to create pairs of B mesons and anti-B mesons and study the origin of matter in the universe.